FRACTURED CHERT SPECIMENS FROM THE LOWER PLEISTOCENE BETHLEHEM BEDS, ISRAEL

J. DESMOND CLARK

BULLETIN OF
THE BRITISH MUSEUM (NATURAL HISTORY)
GEOLOGY Vol. 5 No. 4
LONDON: 1961

FRACTURED CHERT SPECIMENS FROM THE LOWER PLEISTOCENE BETHLEHEM BEDS, ISRAEL

BY

J. DESMOND CLARK

(Rhodes-Livingstone Museum)

Pp. 71–90 ; *Pls.* 15–23

BULLETIN OF
THE BRITISH MUSEUM (NATURAL HISTORY)
GEOLOGY Vol. 5 No. 4
LONDON: 1961

THE BULLETIN OF THE BRITISH MUSEUM (NATURAL HISTORY), *instituted in* 1949, *is issued in five series corresponding to the Departments of the Museum, and an Historical series.*

Parts will appear at irregular intervals as they become ready. Volumes will contain about three or four hundred pages, and will not necessarily be completed within one calendar year.

This paper is Vol. 5, *No.* 4 *of the Geological (Palaeontological) series.*

PRINTED BY ORDER OF THE TRUSTEES OF THE BRITISH MUSEUM

Issued March, 1961 *Price Seventeen Shillings and Sixpence*

FRACTURED CHERT SPECIMENS FROM THE LOWER PLEISTOCENE BETHLEHEM BEDS, ISRAEL

By J. DESMOND CLARK

SYNOPSIS

This paper describes the specimens of fractured chert associated with a Lower Pleistocene fauna recovered during excavations from 1935–40 in a sink or swallow hole at the highest point of the Jordan arch. Analysis shows the cherts to have been fractured by several agencies—heat, percussion and pressure. They are compared statistically with various natural and humanly fractured collections from other areas. The criteria of artificially worked stone—striking platform, bulb of percussion and flat angle of edge-flaking—are absent from almost all the Bethlehem specimens, from which it is deduced that they owe their fractures to natural causes both before and after incorporation in the sink, though the possibility that some of them may have been *used* cannot be entirely ruled out.

INTRODUCTION

THIS paper is complementary to that by Dr. D. A. Hooijer (1958) on the mammalian fauna of Villafranchian age found in the Bethlehem Beds of Palestine during excavations between 1935 and 1937 and again in 1940.

A considerable quantity of chert was found associated with the mammalian fauna. Dr. G. Caton-Thompson had briefly examined the fractured chert specimens from this site and reported (*In* Gardner & Bate, 1937) that some of them conformed closely in shape and edge trimming to the classic Harrisonian eoliths and, therefore, suggested that some of them might be humanly fractured. In view of subsequent investigations into the differences between natural and artificial fracture of stone and into the circumstances under which nature can sometimes simulate human workmanship, a further examination of the Bethlehem stones was considered justified, to see whether the possible human origin of some of the specimens could be confirmed. Accordingly, at the invitation of Dr. K. P. Oakley, the writer made this examination and wishes to express his grateful thanks to the Trustees of the British Museum for giving him the opportunity to undertake this study and making available the excavation reports and drawings, to Dr. K. P. Oakley for his most helpful criticism and advice and for generally facilitating this study, to Miss E. W. Gardner for very kindly checking the section drawing, and to the Keeper of the Department of British and Mediaeval Antiquities, British Museum, for permission to examine the assemblage from the Kafu gravels, Uganda. My thanks are due to the Wellcome Trust for allowing me to make use of the field note-books and photographs of the Bethlehem site which was investigated as part of the work of the Wellcome Archaeological Research Expedition to the Near East, 1935–1937. Special thanks are also due to Miss Rosemary Powers for the illustrations of the Bethlehem specimens that accompany this paper.

It cannot be too strongly emphasized that assemblages of Palaeolithic implements must always be examined in relation to the nature and processes of formation of the deposit in which they are found and to the circumstances under which they have been preserved. Particularly is this important where the assemblage is suspected of dating to the very beginning of tool-making times, since the earliest tools and techniques of stone-working may be expected, by reason of their experimental " crudeness ", to simulate in varying degree naturally fractured stone. Indeed, in the beginning, naturally sharp pieces of stone and specimens worked by the earliest hominids would be likely to have been used indiscriminately and to occur together at the living sites.

The Lower Pleistocene (Villafranchian) age of the Bethlehem fauna, places the associated chert specimens near or even on the boundary line where evidence of the earliest tool-making hominids has been found. Thus it is particularly important that this assemblage should be examined as a whole in the light of present knowledge of the differences between human and natural fracture and an attempt made to distinguish between the possible agencies that brought about the fracture of these specimens.

THE SITE AND STRATIGRAPHY

The following summary of the situation and geology of the site is taken from the excavators' preliminary report (Gardner & Bate, 1937) and from the day books. Well-digging in a garden at the highest point of Bethlehem (790 metres above sea level) from where the country falls away on all sides, brought to light the first mammalian bones 15 metres below the surface in 1934. During three field seasons, in 1935–36 and 37, excavations were undertaken by Miss E. W. Gardner and the late Miss D. M. A. Bate with support from the Trustees of Sir Henry Wellcome and Sir Robert Mond. The excavation was completed by Dr. M. Stekelis in 1940, but no chert specimens from this last season's work were available for examination in London.

The fauna and fractured chert of all sizes occurred in a loose gravel set in a stiff clay matrix which was found under decomposed soil and a superficial secondary limestone. The beds dip, often steeply, to the northeast and south and it appears that they are following a funnel-shaped hole in a hard, lime-cemented chalky scree or breccia known locally as " *nari* ", containing many limestone blocks. The gravel lies against this scree deposit at a steep angle and sometimes penetrates into it as pipes, while on one side the *nari* arches over the gravel. This steeply dipping scree face was followed down for 11 metres to a small platform from where it again plunged downwards. The scree contained no fauna or fractured chert and was clearly formed under sub-aerial conditions long prior to the accumulation of the gravel. Minor constituents of the gravel were limestone blocks and pebbles, especially in places adjacent to the calcareous scree and a few iron nodules. All these materials were little sorted and were mostly derived from local Cretaceous rocks. On one side of the excavation a layer of pure clay, sterile of fauna or chert, separated the gravel into an upper and a lower half but on the opposite side this clay lenses out and it can be seen that the gravel is all of one age.

In places where some protection has been afforded to it, as, for example, on the platform mentioned above, a grey bone-bearing gravelly clay is found between the gravel and the wall of the cemented scree. It would seem that this was formed somewhat later than the main deposit of red coarse gravel.

At one place, also, a 6-metre deep pipe was found penetrating the cemented scree and filled with angular blades (*sic*) of chert of all sizes set in a red, gritty clay matrix. On the south side near the base of this pipe and caught up in pockets of red clay in the *nari* were found some highly polished and glazed chert pebbles mixed with quite unworn and angular fragments.

The gravels rapidy contract with depth. When taken in conjunction with the inward dip of the beds, this fact made the excavators conclude that the gravels formed the filling of a roughly funnel-shaped hole or sink, or alternatively that they had reached their position as a result of the collapse of the original floor on which they were laid. Sliding and slumping of the deposit in some places confirms that collapse of the floor of the sink had taken place after or during the process of gravel filling.

Included as an Appendix is a report by Dr. S. H. Shaw, then Geological Adviser to the Government of Palestine. This followed from his examination of the site during the 1940 excavations and confirms Miss Gardner's interpretation of the nature of the deposits. There is, however, some disagreement as to the importance of the part played by water in the accumulation of the gravel and clay. The deposits are clearly not waterlaid in the sense of their having been accumulated by river or stream action, yet the abrasion of most of the chert specimens is such that they are likely to have acquired this in the course of general terrestrial weathering. This weathering probably occurred while they were lying on the surface prior either to being washed by stormwater or falling into the sink while this was gradually collapsing and filling up over an appreciable period of time. The sink was formed as a result of local solution of the *nari* but the comparative rarity of limestone fragments in the gravel and clay, except in the lower levels and in the parts adjacent to the *nari*, of which they form an integral part, shows that while purely residual elements were an important contributory factor to the filling of the hole, the main part of the gravel was derived from the surface outside.

The deposit is mainly, therefore, in the nature of an eluvial accumulation such as might be expected to have resulted from intermittent and fairly rapid run-off under semi-arid rather than consistently wetter conditions. The chert shows signs of having been subjected to many mechanical forces—striation, shattering, bruising, crushing, rolling and thermal action. Generally speaking, however, the amount of typical abrasion by water rolling is very slight and a considerable proportion of the specimens are relatively fresh while a few are completely so.

It is interesting to note that the faunal remains, which occur from 1·75 metres to 15 metres down in the gravel, have not been subjected to quite the same amount of mechanical weathering, though they have been subjected to fracture by pressure indicating that some movements must have taken place since their inclusion in the deposit. Moreover, the excavators report that it seemed as if complete carcases may have been embedded in the deposit. Indeed, in Africa, as no doubt elsewhere, it

is not uncommon to find whole carcases of animals that have fallen into sinks perhaps in search of water. The fauna, which contains *Archidiskodon planifrons*, *Leptobos* and *Hipparion* (Hooijer, 1958) indicates a warm climate but with a more liberal supply of permanent water than exists in the region to-day.

Dr. Hoojier's examination shows the animal remains to be all of one age and representative of a basal Pleistocene fauna, which appears to be Asiatic in origin though it provides links for this period between Asia and Africa.

Plate 17 is an attempt to reconstruct the general stratigraphy of the site based on the excavators' reports, photographs and the day books. Unfortunately the detailed section drawings were not available, but Miss Gardner has confirmed that the reconstruction is accurate so far as the main facts are concerned. Plates 15 and 16 show the general situation of the site and details of the stratigraphy.

DESCRIPTION OF THE SPECIMENS

A. *Nature of the Raw Material*

Only the chert shows any evidence of fracture. This material is found in two forms. The one is a tabular chert of varying thickness, the average being between 10 and 15 mm. with pitted or corrugated cortex. In colour it is mainly a pale, greeny brown. The other form is a nodular chert, usually black to grey in colour. Also represented, though rarely, is a brecciated chert in which yellow to cream concretions are set in a red-brown to grey matrix. Acheulian man favoured the use of this latter material at certain sites in southwest Asia.

The chert was found in all sizes—from large blocks measuring half a metre or more to small fragments only a few millimetres long—and was in the main derived from local Cretaceous rocks.

B. *Physical Condition and Patination*

By far the greater majority of specimens have been patinated and abraded by sub-aerial weathering which has rounded and bruised the aretes and edges before incorporation in the gravel. Very few pebbles or specimens in the collection show the higher degree of abrasion that results from long incorporation in a stream gravel though some pebbles (of limestone) do occur. The glossy patina seen on certain small pebbles and flaked fragments from the lower part of the deposit has already been referred to. These specimens come from pockets of red clay in the *nari* and show a very high degree of natural glazing. There are no more than two dozen of these specimens but their appearance is strikingly different from that of the remainder of the material. This type of glazing is very similar to that exhibited by tools in many Quaternary river gravels and in some spring deposits in tropical Africa where silica rocks form the chief ingredients. The glaze is generally considered to have been brought about by rapid temperature variation in an environment with a fairly high rainfall having a marked seasonal variation and results from a concentration on the surface of silica derived from the interior of the stone (Phaup, 1932).

Only a very few of the chert specimens show entirely fresh edges and lack of abrasion and from these some interesting deductions are possible. Numbers of the abraded specimens, however, show varying degrees of localized fresh fracture, and this

differential abrasion is one of the most significant features of the collection. Specimens thought most likely by the excavators to have been artificially fractured were found in a red pebble bed some ten metres down, where was also found the fragmented carapace of a giant tortoise, and also from the western end of the north face. In the pipe in the *nari*, known as "the chert plug", containing a quantity of angular chert blocks set in red clay matrix, occur many examples which have been fractured *in situ* by pressure. The scars are quite fresh and in several instances the pieces which had been removed were only a few millimetres away.

The collection also contains four fragments of freshly broken hard limestone, pink in colour and one chert fragment showing a bulb of percussion. These are labelled as coming from the bone area on the north side of the excavation, where was a fan-shaped mass of clay. They appear to be geological samples collected by the excavators and so have not been included in the analysis.

C. *The Categories*

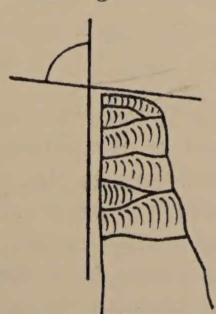
Definitions :

The following terms have been used in the text as defined below.

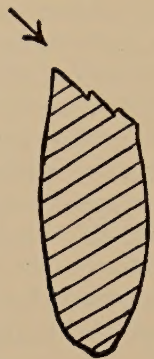
1. Specimens have been approximately classified according to shape when laid flat on a table as follows—

   Sub-rectangular
   Square .
   Triangular
   Oval .
   Irregular (Not falling into any of the above categories.)

2. Length—the length of the longest rectangle into which a specimen can be fitted.
3. Breadth—the breadth of this rectangle.
4. Flake—exhibiting a striking platform, bulb of percussion and other characteristics of percussion or strong pressure flaking. Length-breadth ratio between 5 : 2 and 5 : 5.
5. Psuedo-flake—apparently exhibiting a main flake surface but with no surviving evidence of striking platform, bulb or concentric rings.
6. Flaking- or platform-angle—the angle made by the striking platform and the main flake surface.
7. Angle of edge-flaking—the average angle made by the intersection of the under or main flake surface with the edge trimming on the upper face, i.e.



8. Unilateral flaking—that which is directed from one face only, i.e.



9. Bilateral flaking—that which is directed from both faces of the specimen on the same part of an edge, i.e.

10. Multi-directional flaking—that which is exhibited by specimens that have been flaked from more than two directions.
11. Eolith—fractured flints from " Pre-Glacial " plateau drift and the East Anglian Crags which were at one time considered to exhibit human workmanship but which today are generally agreed to be natural, having been flaked by soil creep and pressure.

In the following analysis of the material every specimen collected has been noted and included in the tables irrespective of whether it exhibits any fracture or not. The percentage of unfractured specimens to the whole collection is of course very much larger than the table indicates since it was clearly impracticable for the excavators to preserve everything in this category. The measurements of those preserved are, however, useful for comparison with the fractured specimens. For analysis specimens have, therefore, been divided into five groups :

		Percentage of total
(1) Unfractured specimens	85	27·3
(2) Thermally fractured specimens	11	3·5
(3) Specimens on tabular chert	37	11·8
(4) Specimens on nodules and lumps	103	33·2
(5) Flakes and pseudo-flakes	75	24·2
Total	311	

(1) *Unfractured Specimens* (85)

These consist predominantly of much weathered and rounded concretions of chert, limestone or iron-stone and show no evidence of any localized battering or abrasion. A few pebbles are included but these are more in the nature of rounded, sub-angular pieces of chert and limestone rather than river cobbles. A few fragments of tabular chert and limestone also come into this group. It is likely that many more such pieces were found in the deposit, especially in those parts adjacent to the *nari* or scree where angular limestone blocks were most numerous.

Length	Maximum 15 cm.	Minimum 3 cm.	Average 4·5 cm.
Breadth	„ 10 „	„ 2 „	„ 4·3 „
Thickness	„ 8 „	„ 2 „	„ 3·4 „

(2) *Thermally Fractured Specimens* (11). Plate 18, figs. 1 and 2

These are mainly fragments of tabular chert, sub-rectangular or oval in shape and with rounded edges. Most show evidence of a thickish patina, white to cream in colour, which has been reddened presumably due to fire. Some specimens show incipient surface gloss. Five specimens exhibit typical closed ring and cup fracture accompanied by a mottled grey to purple patina. Two specimens show the crackle markings resulting from incorporation in a fire while from another heat spalls have been removed from both faces giving the appearance of bilateral flaking. A few of the specimens in the other categories also show clear evidence of thermal fracture as well as that from other causes. In addition it is strongly suspected, but cannot be proved, that a number of the " pseudo-flakes " listed under group (5) below had their flake surfaces produced by heat fracture.

There is no evidence that any of these specimens were fractured by fire after incorporation in the gravel in the sink. Rather is there every indication that the fracture had occurred before they found their way into the deposit. It is suggested, therefore, that bush fires were the probable agency for the fracture of these specimens. The action of such fires in the splitting and cracking of rocks can be readily observed in the field in the tropics.

(3) *Specimens on tabular chert* (37). Plate 18, figs, 3–7

These are mainly small fragments of no consistent shape and the angle of intersection of the edges with the two faces is very often nearly a right-angle. The edges of most of them show steep " nibbled " working intermittently all round the specimen.

It is noticeable that frequently this retouch has been directed sometimes from the one, sometimes from the other face, but very rarely from both faces at once to produce normal bilateral flaking. Notching is a common feature, again associated with " nibbling " and bruising directed from one face only. It is apparent that the " all-round retouch " on these specimens was not produced at one time, since the degree of weathering or freshness and the patina are variable. Only a few examples show quite fresh fractures or fresh " nibbling ". It would seem, therefore, that most of this " nibbled " working must have taken place before the specimens became incorporated in the sink and that it is only the fresh fracturing that took place after or at the time of this event. Since there is no indication that the fauna, which was interstratified with the chert specimens, can have moved much once it had found its way into the sink, it may be assumed also that the only agency that could effect fracture of rocks *in situ* in this deposit would be pressure, aided perhaps by some collapse of the floor of the sink and by frost action.

By far the largest number of the tabular specimens can be classified as sub-rectangular in shape. Eight are triangular, six are oval, one is square and five are irregular. Measurements are as follows :

Length	Maximum 12·5 cm.	Minimum 3·7 cm.	Average 6·7 cm.
Breadth	,, 9·5 ,,	,, 2·4 ,,	,, 4·6 ,,
Thickness	,, 5·7 ,,	,, 1·0 ,,	,, 2·5 ,,
Angle of edge flaking	Maximum 98°	Minimum 50°	Average 84°

Eighteen specimens show trimming from one or part of one face only while nineteen have the edges trimmed intermittently from both faces—sometimes from one, sometimes from the other, but rarely from both faces at once. Three of these specimens exhibit fresh or near fresh fracture and only incipient bruising or " nibbling " of the edge. The angle of edge flaking in these last is low, between 61° and 79°. It is probable that the absence of continued pressure on the edges of these specimens had preserved them from reduction to the near right angle found in most of the other specimens.

(4) *Specimens on nodules and lumps* (103). Plate 19

These vary considerably in size but on average agree well with the first group. The majority are angular nodules showing signs of bruising and abrasion such as results from eluvial action and it is clear that they must have received this treatment prior to their inclusion in the sink. Again, however, a prominent feature is differential abrasion and patina and this weathering undoubtedly came about at several different times. Often the nodule or lump had broken either down the long or short axis or even along both and the sharp intersections so produced have in their turn been subject to pressure, percussion fracture and bruising. Measurements are as follows :

Length	Maximum 17 cm.	Minimum 2·4 cm.	Average 6·2 cm.
Breadth	,, 13 ,,	,, 2·3 ,,	,, 4·8 ,,
Thickness	,, 9·5 ,,	,, 2·0 ,,	,, 3·7 ,,

Most of these nodular specimens have no particular shape and so have been classed as irregular (50). Some, however, are more uniform; 22 can be described as sub-rectangular, 23 are oval and 8 triangular in form. Edge-trimming is from one side only in 38 specimens and from two or more faces in 53. In the remainder there is no clear trimming from an edge.

Angles of edge flaking (measureable only on 76 specimens) vary from 42° to 107° with an average of 91°.

There is a marked absence of any opposed alternate flaking of an edge such as is found on the Pre-Chelles-Acheul tools of Oldowan and developed Kafuan type. On two specimens only (Plate 19, figs. 5, 6) is there any evidence of this and in both it is apparent that the flakes have been removed at quite different times with a resulting difference in physical condition.

Evidence of percussion fracture can be seen definitely on three specimens only. One abraded specimen has been struck in the centre of one side, the blow removing a flake from part of this face and producing a semi-cone of percussion (Plate 19, fig. 1). On one quite fresh and unabraded specimen a cone of percussion indicates that the block of chert from which it came must have been struck fairly heavily to produce a cone of this size (Plate 19, fig. 2).

The most "evolved" form is a heavily leached and white patinated specimen which approaches the "rostro-carinate" type of eolith, with a flat base (or ventral surface) and a high back (or keel) giving it a triangular cross-section (Plate 19, fig. 6). The flaking on this specimen, however, shows differential physical wear and has been directed in most cases from the ventral surface.

(5) *Flakes and Pseudo-flakes* (75). Plate 20

Only fifteen specimens show a striking platform and bulb of percussion, thus preserving a flaking-angle that can be measured. Only this number, therefore, give clear evidence of having been produced either by percussion or by pressure (Plate 20, fig. 1). In every other case, either later fracture has removed the bulb and platform (Plate 20, fig. 2), if indeed these existed, or the "flake" surface is flat and smooth and shows none of the unmistakeable evidence of percussion fracture. Such specimens are referred to here as pseudo-flakes (Plate 20, fig. 3).

Some of these flakes may be of the kind obtained in the initial flaking of a pebble either by nature or man, although the Bethlehem specimens show no clear evidence of this. In such cases either a much restricted bulb and bulbar scar are present or, if the rock is coarse-grained, shatter lines and crushing at the point of impact betray the nature of the force that produced the fracture. In these cases the angle between the flake surface and the pebble cortex is an acute one (Clark, 1958).

Since some of these pseudo-flakes present an undulating or wavy flake surface and a total absence of concentric rings, it is suggested that they may be due to thermal fracture. Bush fires, or sudden heating and cooling can produce such splitting of rocks under tropical conditions and, when we take into consideration that they occur with specimens that were unquestionably fractured by fire, it seems probable that fire may also have been responsible for producing a large proportion of these pseudo-flake surfaces.

The measurements of specimens are as follows :

Length .	. Maximum	17·0 cm.	. Minimum	3·8 cm.	. Average	7·6 cm.
Breadth	. „	15·0 „	. „	0·7 „	. „	6·5 „
Thickness	. „	6·0 „	. „	1·6 „	. „	3·0 „

Specimens may be classed as triangular (25), sub-rectangular (15), oval (18) and irregular (17) in form.

Platform angles of flakes vary between 81° and 122° with an average of 99°. In most instances platforms are negligible and in only two specimens is there a wide enough platform to indicate that the flake may have been removed by a swinging percussion blow.

The angle of edge flaking measurable on 70 specimens varies from as little as 57° to 96° and the average, as might be expected, is as high as 82°.

In 32 specimens the trimming comes from one face or part of one face only and in 37 flaking comes from both faces. Five examples show no secondary trimming, while only one shows incipient bilateral flaking to form a simple wavy cutting edge.

The edge trimming is steep and is similar to that seen on the tabular specimens.

D. *The Nature of the Flaking*

The above description shows that fracture of the chert specimens in this collection has been brought about in several different ways and at different times.

(i) *By percussion.* The characteristics of percussion fracture—cones and semi-cones, fairly pronounced bulb and concentric rings, and sometimes bulbar scar—are rare in the Bethlehem collection. Twenty per cent. of the flakes show a bulb and striking platform but in most cases the platform is narrow, the bulb is flat and the bulbar scar is absent. Such characteristics are much more suggestive of pressure than of percussion fracture.

Only a small percentage also of the flaked nodules and lumps show true negative flake scars and there is hardly one of these that shows a deep negative scar—unmistakable indication that it has been fractured by direct percussion. Where such a scar is present it is clear that the bulb was invariably shallow, again a feature more characteristic of flaking by pressure.

As mentioned above, however, one fresh lump (Plate 19, fig. 2) shows a very good cone of percussion at one end and another specimen (Plate 19, fig. 1) exhibits a semicone. In the case of the first example fracture must have come about after, or immmediately before incorporation in the sink. The second example was subjected to eluvial abrasion and weathering before inclusion in the deposit. Both these specimens had been struck in the centre of the block—in the first example the blow was sufficiently strong to detach fragments from all round the circumference but in the second it was insufficient to shatter the pebble and only one small flake was removed.

One small nodule (Plate 19, fig. 4) has been split in half but there is no sign that this is the result of percussion. However, this half nodule has been truncated at one end by the removal of a single percussion-struck flake. The edges in some places show incipient " nibbling " such as follows from pressure, induced, no doubt, by the weight of the overlying deposit.

Only 0·7% of specimens show any clear evidence of percussion fracture, therefore.

Recent examination of naturally fractured pebbles in the Batoka Gorge of the Zambezi river has shown that simple and even more elaborate fracture, closely simulating that exhibited by the so-called Kafuan Culture of Africa, can be brought about by rocks falling from a height on to pebbles wedged in gravel below (Clark, 1958). It is suggested, therefore, in the case of the quite fresh specimens from Bethlehem believed to have been struck and fractured by percussion when they were already in the sink, that this fracture was brought about either by rocks or stones falling on to them from above or when they themselves fell into the sink.

Stone that has been subjected to temperature stresses from long exposure on the surface is much more readily split along the lines of weakness than is "fresh" stone, as even the earliest tool-makers were not slow to appreciate. If, therefore, the Bethlehem deposits represent the slowly accumulating fill of a sink brought about by the washing in of eluvial material from the surface above and by gravitation then it is easy to see how the small amount of percussion fracture exhibited by the specimens lying in a deposit which sometimes contains blocks half a metre in diameter was probably brought about.

Even the earliest tool-makers appreciated that if it is required to remove a flake from a stone or pebble to produce a sharp edge it is necessary to strike the pebble a glancing blow away from the centre of the block and not towards the centre as is the case with the two specimens mentioned above.

(*ii*) *By heat.* Most of these specimens had been weathered before they found their way into the sink. In three specimens, however, the cup markings and other evidence of thermal fracture is fresher. It seems improbable that this kind of fracture can have been brought about naturally once the specimens were in the sink. It follows, therefore, that either these three examples became incorporated in the deposit shortly after having been subjected to heating and fracture on the surface or one must invoke human agency. There is no evidence that any Lower Pleistocene hominid knew how to make or use fire and its earliest known use is in the Middle Pleistocene by *Sinanthropus* at Choukoutien (Oakley, 1957). It would seem, therefore, that the fires that produced the Bethlehem specimens cannot have been man made.

(*iii*) *By pressure.* The characteristics of pressure flaking may be summarized as being a small to insignificant bulb, only a very insignificant, or no striking platform, and wavy or rippling concentric rings on the main flake surface. The flakes and blades are generally flat and thin and very often, but by no means universally, microlithic in proportions.

Approximately 57% of the Bethlehem specimens show evidence of pressure fracture. This is of two kinds depending on whether the pressure was strong or weak. Sometimes a sizeable flake has been removed from a core by strong pressure but more often the pressure has been weaker and is confined to "nibbling" along part or all of an edge. The results of strong and weak pressure flaking can be seen on both weathered and fresh specimens. Plate 19, figs. 3, 5, and Plate 20, fig. 1 are examples of primary pressure working. Plate 20, fig. 1 suggests at first that it is a large, percussion-struck flake-blade but the insignificant bulb and near right angle to the platform

indicate that pressure and not percussion is more likely to have been responsible. It is the only large specimen of its kind in the collection. The split nodule or pebble illustrated in Plate 19, fig. 5 is one of the very few specimens showing bilateral flaking. The differential abrasion of the aretes indicates, however, that this flaking occurred at more than one time. The shallow scars, rippling of the concentric rings and parallel nature of the negative scars on the one face show that pressure was most probably the agency that removed these flakes.

Plate 19, fig. 3 is a quite fresh, flat, triangular piece of chert having a superficial resemblance to a micro-blade core in that one, probably two, bladelets had been removed from the apex down one edge. Some bruising of the opposite end of the specimen indicates, however, that these blades were almost certainly removed by pressure onto the apex from above thus forcing the blades from the edge of the fragment which must have been wedged in a vertical position in the deposit.

"Nibbled" flaking of edges, or parts of edges by pressure can be seen in a high proportion of the specimens in the collection. This is particularly well demonstrated on the tabular chert specimens (Plate 18, figs. 2–7) and on a proportion of the flakes and pseudo-flakes (Plate 20, fig. 2). Both weathered and fresh specimens with "nibbled" pressure flaked edges are found. In most cases the flaking has not all been done at the same time and takes the form of simple notching and concave edges such as may result from the compaction of a bed of angular gravel under pressure.

E. *Comparisons and Conclusions*

It is apparent that direct percussion (0·7%) played a very negligible part in the fracturing of these cherts. On the other hand thermal fracture is conclusively proved for 5% of the specimens and is strongly suspected to have been responsible for a much higher proportion (for example many of the pseudo-flakes) though this cannot be confirmed with certainty. The great majority of specimens have been fractured by pressure, mainly applied to the edges of flakes, pseudo-flakes and tabular fragments so as to produce steep angles of edge-flaking.

The late Mr. Hazeldine Warren made a detailed study of the ways in which this type of fracture is brought about in nature and clearly demonstrated, both by experiment and in the field, how pressure from the weight of overlying deposits or their gradual compaction, collapse and movement due to soil creep or solifluction were the main causes of fracture of the East Anglian and other "eoliths" (Warren, 1914). The Bethlehem specimens present similar features of natural pressure flaking (notching, "nibbling" and multi-directional flaking) and indeed such fracture is demonstrated beyond all doubt in the natural fragmentation of blocks in the "chert plug" at this site.

Typical fracture of this kind is found also in tropical and sub-tropical regions in the vicinity of pans and water courses or on specimens incorporated in scree or spread out over flats adjacent to the source of supply of tabular rocks such as flint, chert, chalcedony, indurated shale or ironstone. Much of this kind of steep "retouch" can be shown to be the result of natural causes as listed above but some of it, sometimes, is certainly humanly produced. This can be seen, for example, in industries of Hope Fountain-type from Africa south of the Sahara or in the Khargan and Epi-

Levalloisian industries of the Kharga Oasis in the western desert (Caton-Thompson, 1952). Even so, it is by no means certain that natural agencies have not played some part in producing the all-round " nibbled " and steep retouch observed on tools belonging to some of these industries ; for example on many of the tools from the scree deposits at Hope Fountain itself or at Gwelo Kopje in Southern Rhodesia (Jones, 1929). This can be checked against similar industries from other sites where natural fracture can be excluded and where it can be seen that the angle of edge flaking is much more acute (Clark, 1960).

However, at least a few sites in Africa remain where the angle of edge flaking on these " nibbled " flakes is characteristically steep (i.e. Broken Hill, lowest floor (Clark, 1960) ; Olorgesaile(Posnansky, 1959) and Isimila (Howell, Cole & Kleindienst, 1959)), where man, not nature, was the tool-maker ; In Europe the same can be said for a proportion of the secondary trimming of flake tools of the Clacton industry from the type site (Warren, 1951).

In each of these industries there is abundant proof, however, of percussion fracture and the intentional production of flakes from cores.

At Bethlehem, on the other hand, the almost complete absence of characteristic percussion flaking would seem to rule out human agency as the cause of the fracture of the chert specimens. The pseudo-flake surfaces are most probably of thermal origin while the differential patina and wear point to movement in eluvial gravel and scree before and pressure of overburden after incorporation in the sink, as being the two main ways in which they were broken and " retouched ".

Barnes' (1939) isolation of the angle platform-scar as being one of the most significant criteria in distinguishing between naturally and humanly fractured stone is fully confirmed by the Bethlehem analysis. The term *angle of edge-flaking* used earlier by Hazeldine Warren has been adopted here, however, since it conveys more clearly the nature of the angle under consideration and obviates any confusion with the *platform angle*. Statistical comparisons of the angles of edge-flaking of the Bethlehem specimens were made, therefore, with the following collections in order to try to determine where the closest similarities lay—East Anglian "eoliths", Lower Eocene flaked flints, Kafuan specimens from the Kafu river, Uganda, Pre-Chelles-Acheul flaked pebbles from the Kalomo river, Northern Rhodesia and flake-tools of Late Acheulian Age from Kalambo Falls, Northern Rhodesia. Comparison was also made between the lengths and breadths of Bethlehem flakes and pseudo-flakes with those of the Late Acheulian flake-tools from Kalambo Falls. Acheulian flake tools were selected for this comparison because there is no doubt as to their having been made by percussion fracture and retouched, sometimes steeply, by man. Since the total number of specimens from Bethlehem was only 311 and only 180 of these exhibited flaked edges of which the angle could be measured and since the number of eoliths, Eocene and Kafuan specimens, available to the writer for comparison were also small, the results must be considered as indicators of probability only, though it is not anticipated that they would be greatly different were fully representative samples available.

Plate 21 shows histograms of the frequency distribution of angles of edge-flaking of the Bethlehem specimens and the five groups listed above.

The greatest number of angles of edge-flaking at Bethlehem are between 80° and 90° and the same can be shown to be the case for the East Anglian eoliths and the small number of Eocene specimens.

On the other hand, the angles of edge-flaking of the Acheulian tools lie most frequently between 55° and 65°, thus confirming Barnes' findings for eoliths, natural fractures and sixteen human industries (Barnes, 1939). There can be no doubt that the associations of the Bethlehem specimens are with the naturally fractured forms. On the other hand, the Kalomo pebble tools have the greatest frequency between 65° and 75° with a minor peak between 82° and 84° and the Kafuan tools from Uganda show two frequencies—between 60° and 70° and between 80° and 90°. This it may be suggested, though the sample is insufficient to prove it, indicates that the so called Kafuan Culture is in part the result of natural and in part due to deliberate fracture ; it is thus in general agreement with Bishop's (1959) analysis of Kafuan split pebbles though, as the latter points out, such intentionally fractured pebbles as do occur with these Kafuan assemblages are usually *on* not *in* the gravels and so are of Upper Pleistocene age. It would seem from the histogram of the Kalomo tools that these belong with the humanly fractured groups as is to be expected, though the percentage of specimens with angles between 80° and 90° suggests that a number of these also may have been fractured by natural causes.

Comparison of the lengths and breadths of the Bethlehem and Kalambo Falls specimens (Plate 22) shows that these are more concentrated and less dispersed in the humanly worked tools. This greater variation and diffusion of the Bethlehem examples can be seen again when plotted graphically Plate 23. These patterns can probably be interpreted as, on the one hand, confirming the intentional nature of the human flaking which shows itself in the use of a traditional technique thus limiting and concentrating the frequency distribution of the flake form and on the other emphasizing the absence of any such intentional technique and the proof of the existence of more than one agency of fracture for the Bethlehem specimens.

Such comparisons confirm the evidence from the detailed observations and measurements given above, that all the Bethlehem specimens are naturally fractured and that there is no indication from any of them that an early tool-making hominid was living in this region contemporaneously with the Villafranchian fauna. This conclusion is based on the following characteristics which, when found in combination in collections of earlier Pleistocene age, can be taken as forming conclusive proof that a non-human agency has been responsible for their fracture : Absence or very low percentage of flakes with striking platforms and bulbs of percussion, high angles of edge-flaking, "nibbling" and notching of edges by pressure, multi-directional, but very rarely bilateral flaking, differential abrasion and patina of flake scars, the rarity of percussion flaking and general frequency of pressure flaking.

While, therefore, no evidence can be deduced from the Bethlehem chert collection that their fracture was due to any agency other than nature, this does not exclude the possibility that some of those with suitably sharp edges could have been *used* by some early hominid of Australopithecine form. In this connection it is of interest that Dr. Stekelis recovered during his 1940 excavation a number of broken bones of which he says :

" Special attention was paid to a number of broken bones, belonging to small animals. All these bones are broken in the length and some of them bear marks of ' working '. One piece, having a polished edge, is especially remarkable and may be considered to be an awl. If this piece had been discovered in a Paleolithic cave, it would no doubt have been assumed to have been worked with by man. The whole collection amounts to about 30 pieces. For lack of any material to compare them with, I can say nothing more about these broken bones. The bones cannot be considered to have been broken by animals, as, for example, hyenas, as they bear no toothmarks. They may have been broken by pressure ; still, the facts that the breaking is always in the length and that the second part is always missing, do not allow the conclusion that the breaking was done by pressure ; and it almost appears as though the bones were broken for the purpose of extracting the marrow contained in them."

These bones are presumably still in the Palestine Archaeological Museum and it would be of considerable interest to examine them in the light of Dart's " Osteodontokeratic Culture " associated with *Australopithecus* in South Africa (Dart, 1957) If evidence of their intentional fracture can be confirmed it could be that some of the thermal fractures seen on the Bethlehem cherts might show that here man was a fire *user* also.

APPENDIX

GEOLOGICAL REPORT ON THE ELEPHANT PIT, BETHLEHEM

By S. H. SHAW

DESCRIPTION

The main excavation has been in a gravel deposit consisting of angular flint debris (varying in size from fragments a few millimetres in their maximum dimension to blocks 30 cm. or more across) embedded in stiff red or brown clay. It is in this gravel that the bones have been found. In the south wall of the pit this gravel bed is seen to be steeply banked against a more chalky deposit which varies from a fairly solid chalk to a breccia of chalk fragments. This chalky rock is penetrated by fan-like streaks and pockets of red clay with small angular flints.

The red and the brown clays are both very stiff and have a wax-like texture when freshly taken from the ground. They show no sign of any bedding and on washing yield a residue of tiny angular fragments of flint which range down to microscopic size. The brown clay shows frequent films of black manganese dioxide on broken surfaces but this feature was not seen in the red clay.

The macroscopic flint fragments are all angular but without sharp edges. In some cases their edges show flaking and chipping.

The depth of the pit at the time of my visit was 49 feet. The north and east walls of the pit are mainly in gravel.

CONCLUSIONS AS TO THE ORIGIN OF THE DEPOSIT

I consider that this deposit consists of material filling a pipe or pot hole in the chalk that caps the hill at this point. The deposit is therefore a residual one formed practically *in situ* and as a result of the terrestrial weathering and solution of the chalk rock by the agency of rain water.

There is good general evidence to support this view. Chalks of Senonian age occur in the Mount of Olives and run southwards to Bethlehem occupying the high ground to the east of Bethlehem Road. The upper divisions of the Senonian formation contain prominent flint beds and the ground surface is plentifully strewn with flint boulders and stones of all sizes. These are very noticeable along the road to Government House and on the Jerusalem Golf Course to mention only two localities. These boulders do not occur with chalk but clearly represent the results of a long period of terrestrial weathering during which the relatively soluble chalks have been removed by the action of rain water leaving the broken masses of insoluble flint in a clay soil which represents the insoluble residue from the chalk. The Senonian chalks in this district, therefore, are largely covered at the surface by a residual blanket of clay soil with flints probably very similar to the clay-with-flint formation well known in many of the chalk districts of England.

As regards the elephant pit itself, the general evidence given above is supported by the local details which suggest very strongly that at this point the chalk has been locally more soluble and has given rise to a pipe or pot-hole such as are commonly known to occur in chalk formations.

Examination of the pit shows that none of the chalky rock exposed in the pit can be considered as undisturbed or unweathered material. The clay-filled pockets and joints in this weathered chalk are typical of the *in situ* weathering of soft calcareous rocks.

The gravel deposit has clearly been formed at no great distance from the source from which the flints have been derived, otherwise a much greater amount of sorting would have taken place than has been the case. Although the flints have rounded edges, comparison with the general flint debris common in the district suggests that the rounding is not more pronounced than that occurring on pieces that are derived from the residual surface deposits referred to above. It seems certain, therefore, that the gravel represents a scree-like deposit in the emplacement of which water has played little or no part as a transporting agent. The interstitial clay is entirely unbedded and it seems probable that as the pit became deeper as a result of the solution of the chalk, the overlying flint debris descended into the hollow and there became mixed with the residual clay formed by the solution of the chalk.

It is difficult to say whether or not the pit was open at the time the animal remains got into it. A depression or even a local water hole may have existed on the spot but it is just as likely that there was a sudden collapse of the roof once the solution of the chalk had reached a sufficiently advanced stage. It is possible even that the collapse—if it occurred suddenly—may have been caused by the weight of a large animal such as the elephant whose remains have now been unearthed. As the weathering process is a more or less continuous one, the tendency would be for the flint debris to settle gradually deeper and for more material to be added from above.

Such a process of settlement might well account for the shattered state of many of the remains.

In conclusion I append some extracts from Woodward (1912) referring to the occurrence of pipes or pot-holes in England.

> " Such rocks as Chalk, Carboniferous Limestone, may lose, by dissolution in carbonated water, 90 per cent. or more of calcic carbonate." (p. 62.)
>
> " CLAY-WITH-FLINTS
>
> " This term is applied (though not restricted) to an accumulation of unworn flints and red clay that occurs on the surface of Chalk tracts, and lines pipes or cavities, which sometimes extend to a considerable depth. As pointed out by Mr. W. Whitaker, it is a residual deposit due to the dissolution of the Chalk, leaving the flints and earthy matter, which attain a thickness of from 1 to about 5 feet. The pipes extend vertically or obliquely downwards in a more or less circular form, diminishing in size the deeper they occur, and sometimes their extent is indicated in a Chalk-pit by a circular mass or pocket of Clay-with-flints at some depth from the surface, where an oblique pipe has been cut through in the working of the Chalk." (p. 223.)
>
> " Darwin (1881, p. 137, footnote) remarked that the pipes in the Chalk are still in process of formation. ' During the last forty years I have seen or heard of five cases in which a circular space, several feet in diameter, suddenly fell in, leaving on the field an open hole, with perpendicular sides, some feet in depth. This occurred in one of my own fields whilst it was being rolled, and the hinder quarters of the shaft-horse fell in ; two or three cart-loads of rubbish were required to fill up the hole. The subsidence occurred where there was a broad depression, as if the surface had fallen in at several former periods . . . The rain-water over this whole district sinks perpendicularly into the ground, but the chalk is more porous in certain places than in others. Thus the drainage from the overlying clay is directed to certain points, where a greater amount of calcareous matter is dissolved than elsewhere. Even narrow open channels are sometimes formed in the solid chalk. As the chalk is slowly dissolved over the whole country, but more in some parts than in others, the undissolved residue —that is, the overlying mass of red clay-with-flints—likewise sinks slowly down, and tends to fill up the pipes or cavities. But the upper part of the red clay holds together, aided probably by the roots of plants, for a longer time than the lower parts, and thus forms a roof, which sooner or later falls in, as in the above-mentioned five cases'." (p. 64.)

S. H. Shaw.
Geologist.

July 1940

REFERENCES

Barnes, A. S. 1939. The Differences between Natural and Human flaking on prehistoric flint implements. *Amer. Anthrop.*, Lancaster, Pa., **41** : 99–112.

Bishop, W. W. 1959. Kafu Stratigraphy and Kafuan Artefacts. *S. Afr. J. Sci.*, Cape Town, **55** : 117–121.

CATON-THOMPSON, G. 1952. *Kharga Oasis in Prehistory ;* with a physiographic introduction *by E. W. Gardner*. xx + 213 pp., 128 pls. London. [Especially pls. 75–80.]

CLARK, J. D. 1958. The Natural Fracture of Pebbles from the Batoka Gorge, Northern Rhodesia, and its bearing on the Kafuan industries of Africa. *Proc. Prehist. Soc.* Cambridge (n.s.) **24** : 64–77.

—— 1960. Further Excavations at Broken Hill, Northern Rhodesia. *J. R. Anthrop. Inst.*, London, **89** : 201–232.

DART, R. A. 1957. The Osteodontokeratic Culture of *Australopithecus prometheus*. *Transvaal Mus. Mem.*, **10**. viii + 105 pp., 43 figs.

Darwin, C. R. 1881. *The formation of Vegetable Mould, through the action of Worms.* vii + 326 pp., 15 figs. London.

GARDNER, E. W. & BATE, D. M. A. 1937. The Bone Bearing Beds of Bethlehem : Their Fauna and Industry. *Nature, Lond.*, **140** : 431–433, 1 fig.

HOOIJER, D. A. 1958. An Early Pleistocene Mammalian Fauna from Bethlehem. *Bull. Brit. Mus. (Nat. Hist.) Geol.*, London, **3** : 267–292, pls. 32–35.

HOWELL, F. C., COLE, G. H. & KLEINDIENST, M. R. 1959. Isimila : an Acheulian occupation site in the Iringa highlands, South Highlands Province, Tanganyika. [Paper presented at 4th Pan-African Congress on Prehistory, Leopoldville, 1959.]

JONES, N. 1929. A hitherto undescribed Early Stone Age Industry near Hope Fountain, Rhodesia. *S. Afr. J. Sci.*, Johannesburg, **26** : 631–647, 42 figs.

OAKLEY, K. P. 1957. Observations on the earliest use of fire. In C.R. 3rd Pan-African Congress on Prehistory, Livingstone, 1955 (pp. 385–386) Ed. Clark, J. D. & Cole, S. London.

PHAUP, A. E. 1932. The Patina of the Stone Implements found near the Victoria Falls. *Proc. Rhod. Sci. Ass.*, Salisbury, **31** : 40–44, 1 fig.

POSNANSKY, M. 1959. A Hope Fountain Site at Olorgesailie, Kenya Colony. *Bull. S. Afr. Arch. Soc.*, Capetown, **14** : 83–89.

WARREN, S. H. 1914. The Experimental Investigation of Flint Fracture and its application to Problems of Human Implements. *J. R. Anthrop. Inst.*, London, **44** : 412–450.

—— 1923. The Sub-soil Flint-flaking Sites at Grays. *Proc. Geol. Ass.*, London, **34** : 38–42, fig. 4.

—— 1923*a*. Sub-soil Pressure-flaking. *Proc. Geol. Ass.*, London, **34** : 153–175, figs. 19–26.

—— 1951. The Clacton Flint Industry : A New Interpretation. *Proc. Geol. Ass.*, London, **62** : 107–135, pls. 4–7.

WOODWARD, H. B. 1912. *The Geology of Soils and Substrata. With Special Reference to Agriculture, Estates, and Sanitation.* xvi + 366 pp., 4 pls. London.

PLATE 15

A. Bethlehem, general view from the east. The excavation was situated on the highest hill in the centre background. Photograph by E. W. Gardner, 1935.

B. West side of excavation in 1936 showing general nature of the *nari* and gravel junctions.

C. South side of excavation showing slide and vertical junction of gravel and clay at 8 m., 1935.

D. Showing the chert plug (position indicated by ranging rod) in *nari* in southeast corner of excavation in 1936.


A
B
C
D

PLATE 16

A. South side and southeast corner of the " Elephant Pit ", excavated to 10 m., showing from left to right chert plug, white chalky *nari*, limestone breccia overlain by *nari* streaked with clay, gravel " wedge ", breccia block and concave slide (in foreground).

B. Detail of junction of gravel and clay on north face of excavation in 1936.

PLATE 17

Probable north-south section of " Elephant Pit ", Bethlehem.

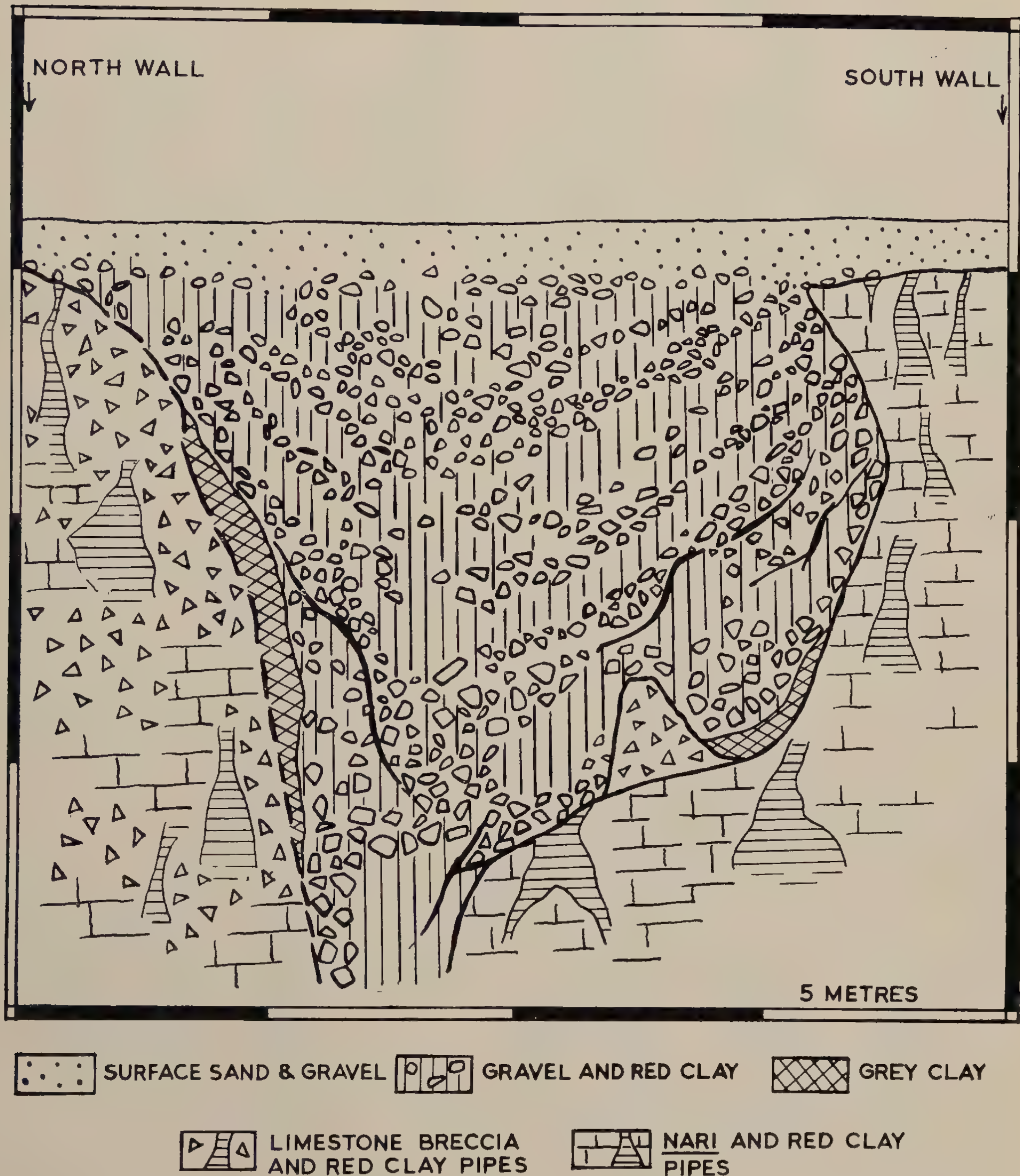

NORTH WALL
SOUTH WALL
5 METRES
SURFACE SAND & GRAVEL
GRAVEL AND RED CLAY
GREY CLAY
LIMESTONE BRECCIA AND RED CLAY PIPES
NARI AND RED CLAY PIPES

PLATE 18

Fig. 1. Fragment of grey tabular chert with thick cream coloured patina reddened on surface by heat: shows cup markings and closed rings typical of thermal fracture, but no flake scars due to percussion or pressure. Condition—fresh and unabraded. E.3772.

Fig. 2. Thermal spall of black to dark brown chert. Remains of thick white cortex at upper end, the surface of which has been reddened by fire. Cup depressions due to heat fracture well seen on both faces. Flaking by pressure has produced two concave nibbled edges. Condition—fresh and unabraded. E.3780.

Fig. 3. Small piece of tabular green-grey chert. Roughened cortex with buff coloured patina. Left edge and base show steep nibbling retouch due to pressure. Condition—fresh but edges bruised and abraded by pressure. Bethlehem 32. E.3778.

Fig. 4. Fragment of green-grey chert. The lower face of the piece having split away under heat exhibits thermal closed rings. Thick creamy coloured patina on upper surface, surface reddened by heat. Two scars show where flakes have been removed from the under face probably by pressure. Two approximately opposed concave nibbled edges are present, both resulting from pressure applied from the under face. Condition—differentially abraded and patinated, the concave trimming being less abraded than the two faces. E.1709.

Fig. 5. Fragment of grey to green-grey tabular chert. Roughened cortex shows creamy grey patina and signs of iron staining. Pressure applied from both faces to different parts of the edges has resulted in steep "all round retouch". Angle of edge-flaking is steep, between 86° and 93°. Condition—fresh but edges abraded by pressure. E.3779.

Fig. 6. Fragment of grey tabular chert. One face shows a thick cream coloured patina the other a thinner grey patina; traces of staining by iron oxides. All round retouch by pressure. Steep angle of edge-flaking, i.e. 86°. Specimen has also been subjected to heat, probably before the edges were flaked, which has caused cracking and slight reddening of the surfaces. Condition—edges abraded by pressure. Bethlehem 43. E.3776.

Fig. 7. Probably a piece from a fragment of grey tabular chert. Upper face is composed of flat cortex with differential buff to cream patina. Under face is a fracture surface, probably the result of splitting by heat and shows a green-brown patina. The base and left edge show steep nibbling, notching and bruising retouch by pressure from the cortex face only. The right edge has been bilaterally flaked from both faces to produce a wavy edge formed by two flake scars on the one face opposed against one scar on the other. Patina of this edge is a green-brown, the flaking at the base is unpatinated. Condition—at least three stages of different patina and abrasion. Bethlehem 31. E. 3777.

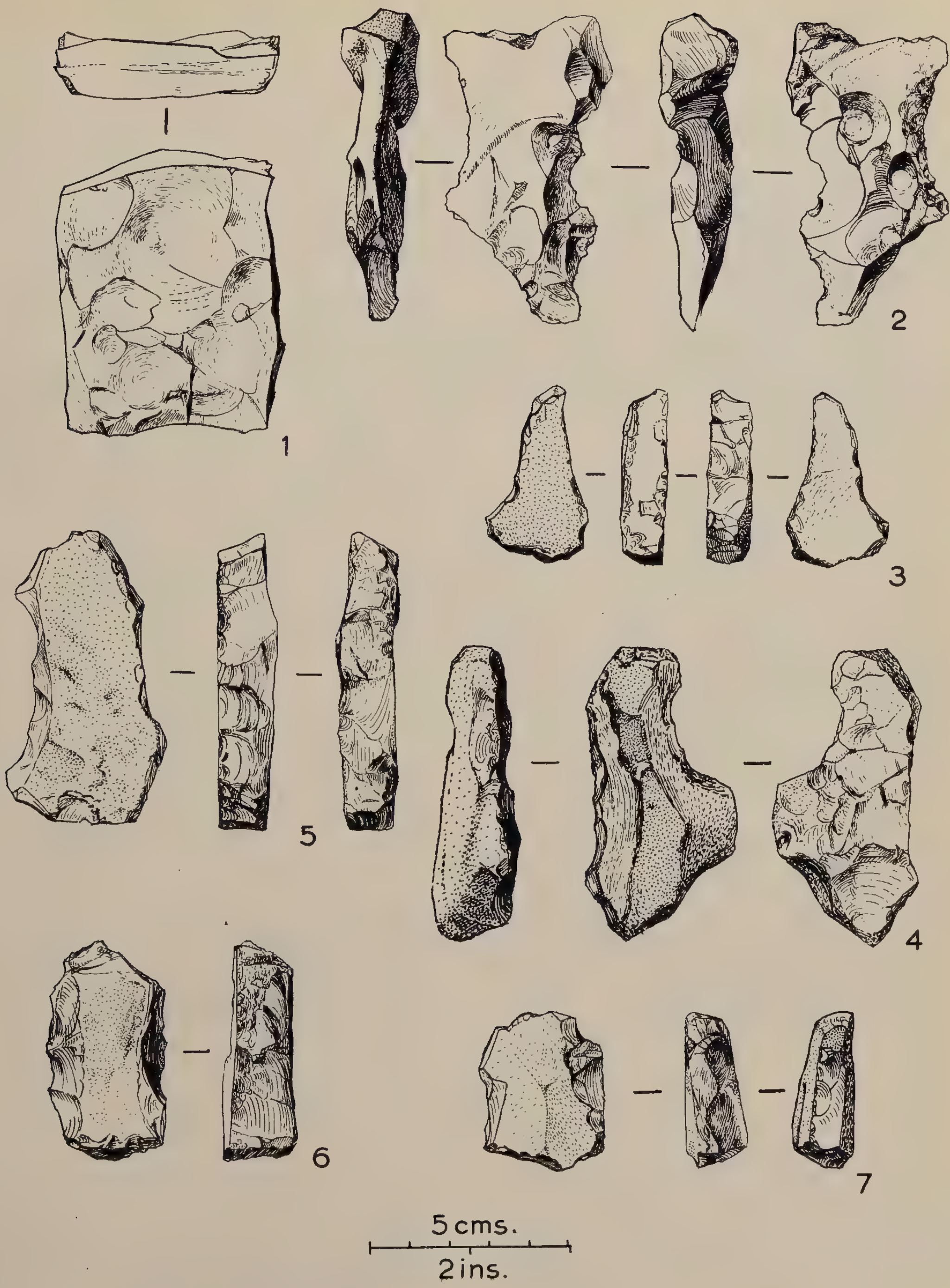

1
2
3
4
5
6
7
5 cms.
2 ins.

PLATE 19

FIG. 1. Spherical nodule of dark brown chert which has been struck a hard blow by percussion in the centre of one face, thus detaching a flake and producing a semi-cone of percussion. The flake scar exhibits characteristic ripple marks. Dark brown patina. Condition—rolled and abraded. E.3768.

FIG. 2. Irregular lump of chert breccia (mottled white and brown) exhibiting one large cone of percussion and scars from flake fragments that have split away due to the hard percussion blow, directed to the centre of the stone, which fractured the lump and produced the cone. The opposite end to the cone shows flaking from both sides of a ridge, possibly the result of pressure on this end at the same time the fragment was shattered. Condition—fresh and unrolled. E.3548.

FIG. 3. Small splinter of brown chert derived from a weathered nodule ; some cortex at lower end. At the upper end evidence of one, perhaps two, small blades having been pushed off down one edge, probably by pressure applied to both ends of the fragment simultaneously. Condition—fresh. Bethlehem 19. E.3568.

FIG. 4. Split half of an irregular nodule of dark brown chert. The cortex shows some abrasion. The split face shows no bulb of percussion and may be due to thermal causes, but one flake, exhibiting good ripple marks on the negative scar has been removed from the top and at right angles to the split face. Fine nibbling and abrasion of the edges in places due to pressure, otherwise quite fresh fracture. Bethlehem 11. E. 3769.

FIG. 5. Small nodule of green-brown chert which has been split and flakes removed from both faces at one end. Nodule had acquired a cream coloured patina before it was split ; patina of fracture green-brown. Fracture consists of one abraded flake scar on the one face opposed to three or more blade scars on the other and nibbling, battering and bruising of this edge. Good ripple marks can be seen on the blade scars. Condition—differential abrasion and patina of the flake scars show that fracture took place on three or more occasions, the specimen suffering abrasion after each one. The angle of edge-flaking is 54°. This is one of the very few examples of bilateral flaking. Bethlehem 12. E.3770.

FIG. 6. Rostro-carinate shaped specimen in chert breccia (white and grey) that has undergone leaching of the stone and exhibits a white patina. Flaking from the ventral face has removed flakes at intervals round two edges. Some flaking also of the ventral face. The keel or dorsal face shows bruising and battering and some incipient flaking near the nose. Condition—abraded. E.3767.


1
2
4
3
5
6
5 cms.
2 ins.

PLATE 20

FIG. 1. Large end-flake of mottled cream and grey chert. Wide striking platform with flaking angle of 91°. Flat and inconspicuous bulb of percussion. The upper face is formed by two fractured surfaces having different degrees of abrasion. These surfaces meet at a central ridge which shows battering. There is no evidence that these surfaces are scars due to percussion or pressure flaking. The upper face is generally more abraded than the under face which is fresh. This shows that the fracturing took place at different times. Bethlehem 49. E. 3540.

FIG. 2. Short thick sub-triangular flake struck from a piece of dark brown tabular chert. Upper face is composed of cream coloured cortex. Under face appears to be a main flake surface though the bulb and striking platform have been removed and parts of two wide flake scars take their place. Nibbled all round retouch by pressure has resulted in a steep angle of edge-trimming, i.e. between 81° and 83°. Condition—the edge-trimming shows a different degree of patina and abrasion from the main flake surface and took place at a different time. E.3543.

FIG. 3. Large psuedo-flake from a rolled nodule or pebble of green chert. The under surface shows no characteristics of percussion fracture and is probably thermally broken ; mottled green-brown patina. Upper face shows a mottled chestnut to white patina. A notch with typical nibbled retouch has been removed from one edge by pressure flaking from the under surface. Angle of edge-flaking is 93°. Condition—under face is more abraded than the notch flaking and the two show different degrees of patination. E.3771.

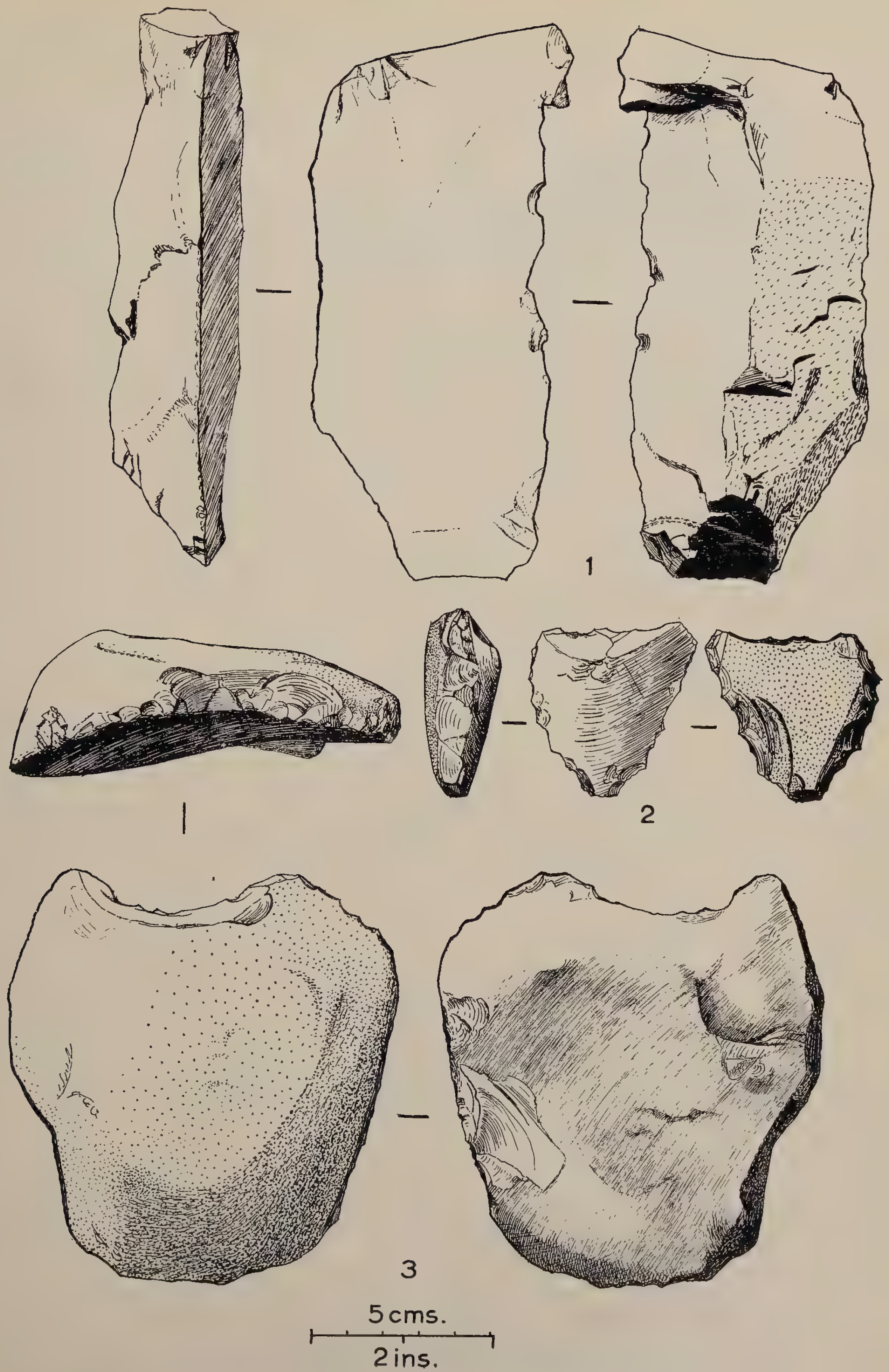

1
2
3
5 cms.
2 ins.

PLATE 21

Frequency distribution of angles of edge-flaking.

FREQUENCY DISTRIBUTION OF ANGLES OF EDGE-FLAKING

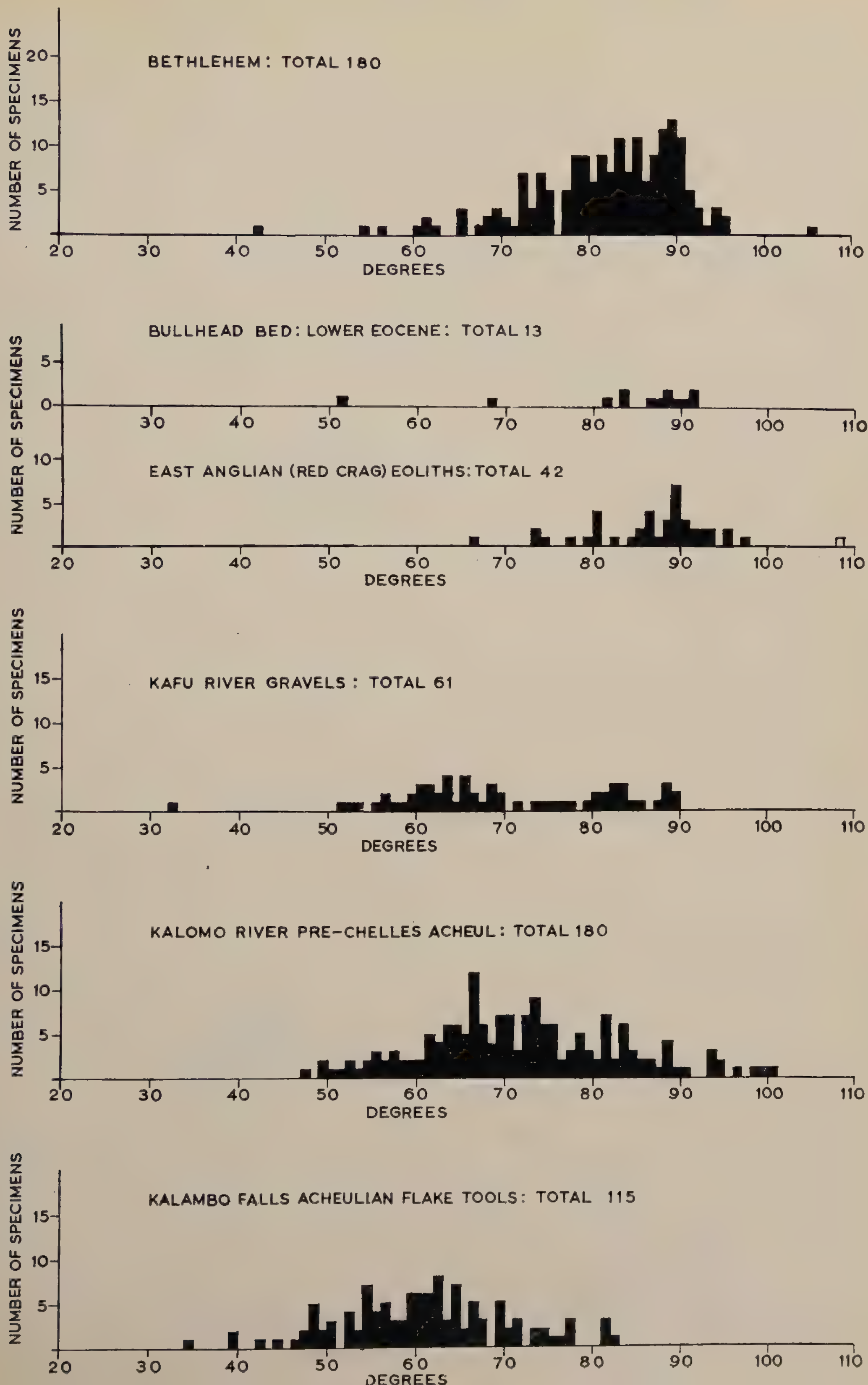


PLATE 22

Frequency distribution : lengths and breadths.

FREQUENCY DISTRIBUTION: LENGTHS AND BREADTHS

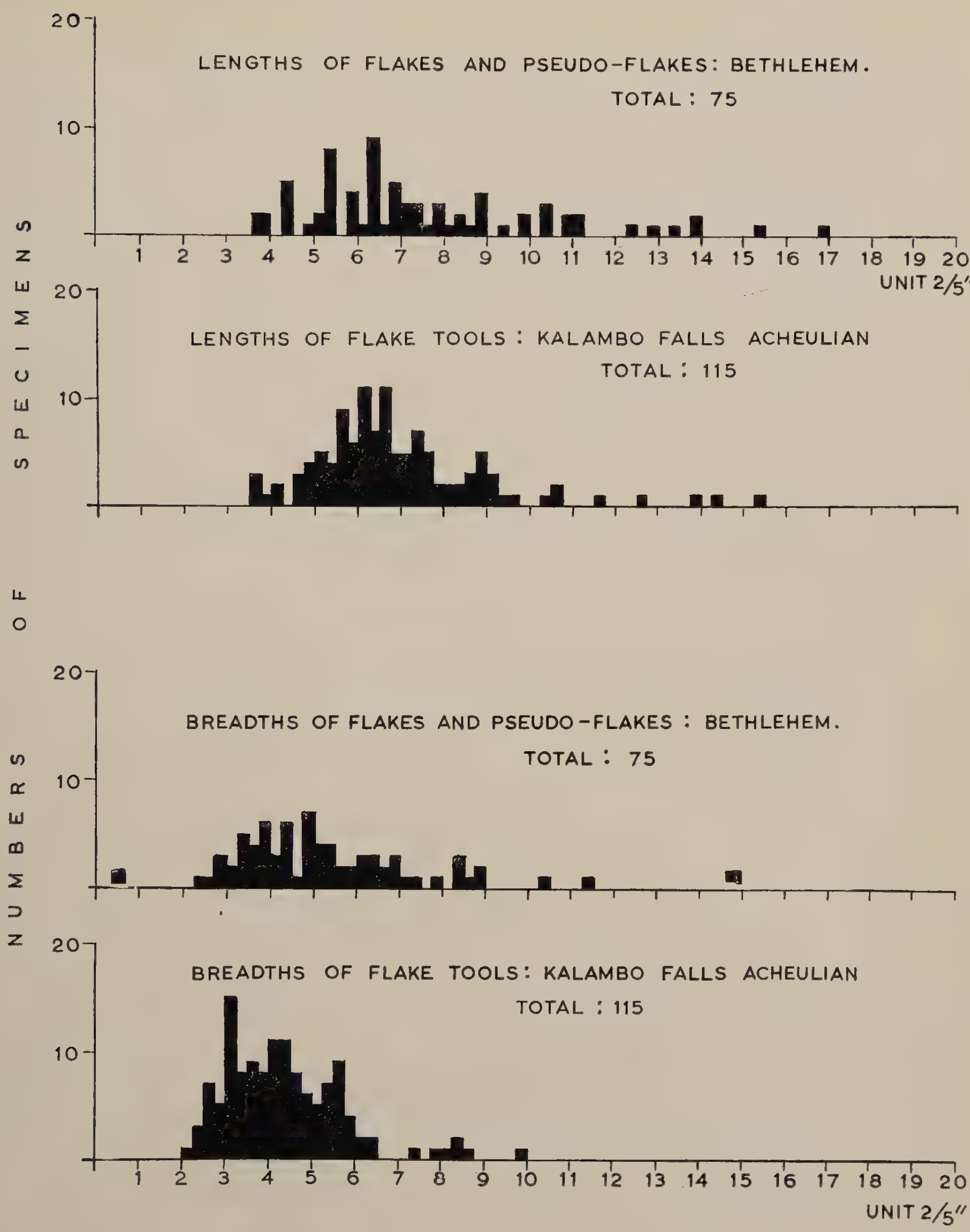
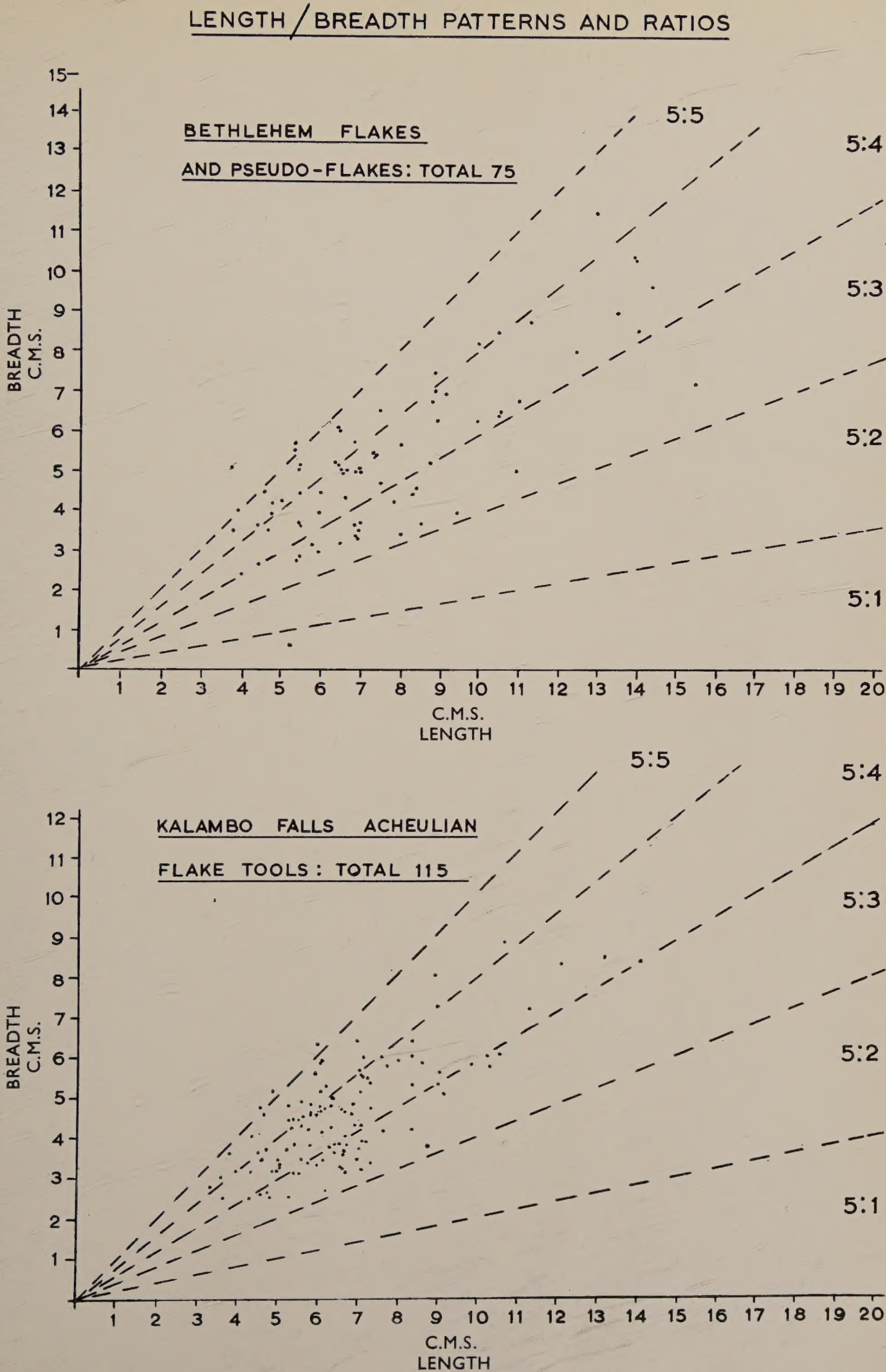


PLATE 23

Length/breadth patterns and ratios



LENGTH / BREADTH PATTERNS AND RATIOS
BETHLEHEM FLAKES
AND PSEUDO-FLAKES: TOTAL 75
BREADTH C.M.S.
C.M.S. LENGTH
5:5
5:4
5:3
5:2
5:1
KALAMBO FALLS ACHEULIAN
FLAKE TOOLS: TOTAL 115
BREADTH C.M.S.
C.M.S. LENGTH
5:5
5:4
5:3
5:2
5:1

PRINTED IN GREAT BRITAIN BY
ADLARD AND SON, LIMITED,
BARTHOLOMEW PRESS, DORKING